DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

2. Claims 38, 45, 54, and 58 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hiramatsu [Fabrication of Carbon Nanowalls using RF Plasma CVD] in view of Goto [US 5980999], Wu [US 20030129305], and Chang [US 5627640].

Regarding claim 38, Hiramatsu teaches a method for producing carbon nanowalls [title] by creating a plasma atmosphere in at least one region of a reaction chamber (main reaction chamber) by plasmatizing a source material containing carbon; introducing radicals generated outside the plasma atmosphere (remote source) into the plasma atmosphere (main reaction chamber), wherein a radical generating area is located outside the plasma generating area (remote H_2 ICP) and is provided H_2 to generate hydrogen radicals (decomposing H_2 radical source to generate hydrogen radicals); and growing carbon nanowalls on a base material (substrate) disposed in the reaction chamber [pg 20]. Hiramatsu also teaches the radicals include hydrogen radicals from a hydrogen source [Hiramatsu, pg 20, col 1].

However, Hiramatsu appears to be silent in teaching the radical-generating area is disposed in the reaction chamber (while being located outside the plasma generating area). Goto remedies this.

Goto teaches a method of introducing reactive gas and radicals to a plasma chamber [abstract], wherein the radical-generating area is disposed in the reaction chamber (while being outside the plasma generating area (109)) [Fig. 1 or Fig. 7], wherein the radical may be a hydrogen radical [col 2, ln 54]. Goto also teaches the radicals are generated by applying microwave, UHF waves, VHF waves, or RF waves [Goto, col 3, ln 20-30].

It would have been obvious to one of ordinary skill in the art at the time of the invention to provide a radical generating area disposed in the reaction chamber as taught by Goto. One would have been motivated to do so to effectively control the density or composition of the radicals [col 16, ln 54-62]. Since Hiramatsu teaches carbon nanowalls were not fabricated without inductively coupled hydrogen plasma [pg 20, col 2], it would have been obvious to one of ordinary skill in the art to provide a means for controlling radical density to provide sufficient plasma of radicals as taught by Goto to create the best yield of carbon nanowalls.

However, although Hiramatsu discloses C2F6 (having carbon and fluorine as 'essential components'), the prior art fails to teach the source material includes hydrogen as a main component. Wu suggests this limitation.

Wu teaches methane (CH_4) may be a suitable carbon building source for forming nanowalls [0042].

And since Wu teaches methane is a known carbon source for producing nanowalls, it would have been obvious to one of ordinary skill in the art to either provide a combination of methane and hexafluorethane as operable carbon gas source for forming carbon nanowalls, since both gases were shown to be effective sources for forming carbon nanowalls; or alternatively, it would have also been obvious to substitute a fluorine for a hydrogen of methane, to yield a fluorinated hydrocarbon such as CHF3 as another carbon source for nanowalls, in light of methane and hexafluorethane being suitable carbon sources for nanowalls.

However, the prior art fails to teach amount of radicals in at least one region is measured. Chang remedies this.

Chang teaches a method for measuring radical species distribution in plasma [abstract].

Since Hiramatsu teaches carbon nanowalls were not fabricated without inductively coupled hydrogen plasma [pg 20, col 2], implying that an amount of hydrogen radicals injected in the plasma would affect the nanowall growth process, it would have been obvious to one of ordinary skill in the art at the time of the invention to measure the amount of actual radicals introduced into the plasma as suggested by Chang. One would have been motivated to do so to better control radical amount, to enhance the growth process and optimize yield of nanowalls.

Regarding claim 45, Goto teaches the feed rate of the source material or feed rate of the radicals may be controlled based upon the density of the radicals in the reaction chamber [Goto, col 5, ln 5-46; col 2, ln 13-20], and since Hiramatsu suggests

the amount radicals affects the production of nanowalls, it would have been obvious to one of ordinary skill in the art to control the feed rate of all radicals or radical amount which is related to radical density in order to produce sufficient nanowalls.

Regarding claim 54, the prior art teaches the carbon nanowalls are successfully deposited on a silicon (100) substrate [Hiramatsu, pg 20] without indication of critically using metal catalyst on the substrate to generate such structures from the process; hence, it would have been inherent that such substrate would have no metal catalyst.

Regarding claim 58, since Hiramatsu teaches C2F6 is an operable carbon source for producing nanowalls, and Wu teaches methane is another known carbon source for producing nanowalls, it would have also been obvious to substitute a fluorine for a hydrogen of methane, to yield a fluorinated hydrocarbon such as CHF3 as another carbon source for nanowalls, in light of methane and hexafluorethane being suitable carbon sources for nanowalls.

3. Claims 38, 45, 54, and 58 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hiramatsu [Fabrication of vertically aligned carbon nanowalls using capacitively coupled plasma enhanced chemical vapor deposition assisted by hydrogen radical injection] in view of Goto [US 5980999] and Chang [US 5627640].

Regarding claim 38, Hiramatsu teaches a method for producing carbon nanowalls [title], by creating a plasma atmosphere using a parallel plate rf, having a plasma generating area (CCP region) by providing carbon gas sources such as C2F6, CH4, or CF4 [pg 4708, col 2]; introducing hydrogen radicals from a remote radical source [pg 4708, col 2] which would inherently include the process of decomposing the

radical source, in this case a hydrogen gas, in a radical generating area, where the radicals are generated by RF waves; to produce carbon nanowalls on a substrate in the PECVD chamber [pg 4708, col 2]. Although Hiramatsu does not explicitly teach the source material comprising carbon, hydrogen, and fluorine together as essential components; since the prior art teaches C2F6, CH4, and CF4 are suitable carbon sources for the production of nanowalls, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide a combination of methane and hexafluorethane as operable carbon gas source for forming carbon nanowalls, since both gases were shown to be effective sources for forming carbon nanowalls; or alternatively, it would have also been obvious to substitute a fluorine for a hydrogen of methane, to yield a fluorinated hydrocarbon such as CHF3 as another carbon source for nanowalls, in light of methane and hexafluorethane being suitable carbon sources for nanowalls. However, Hiramatsu appears to be silent in teaching the radical-generating area is disposed in the reaction chamber (while being located outside the plasma generating area). Goto remedies this.

Goto teaches a method of introducing reactive gas and radicals to a plasma chamber [abstract], wherein the radical-generating area is disposed in the reaction chamber (while being outside the plasma generating area (109)) [Fig. 1 or Fig. 7], wherein the radical may be a hydrogen radical [col 2, ln 54]. Goto also teaches the radicals are generated by applying microwave, UHF waves, VHF waves, or RF waves [Goto, col 3, ln 20-30].

It would have been obvious to one of ordinary skill in the art at the time of the invention to provide a radical generating area disposed in the reaction chamber as taught by Goto. One would have been motivated to do so to effectively control the density or composition of the radicals [col 16, ln 54-62]. Since Hiramatsu teaches carbon nanowalls were not fabricated without inductively coupled hydrogen plasma [pg 20, col 2], it would have been obvious to one of ordinary skill in the art to provide a means for controlling radical density to provide sufficient plasma of radicals as taught by Goto to create the best yield of carbon nanowalls.

However, the prior art fails to teach amount of radicals in at least one region is measured. Chang remedies this.

Chang teaches a method for measuring radical species distribution in plasma [abstract].

Since Hiramatsu teaches carbon nanowalls were not fabricated without inductively coupled hydrogen plasma [pg 20, col 2], implying that an amount of hydrogen radicals injected in the plasma would affect the nanowall growth process, it would have been obvious to one of ordinary skill in the art at the time of the invention to measure the amount of actual radicals introduced into the plasma as suggested by Chang. One would have been motivated to do so to better control radical amount to enhance the growth process and optimize yield of nanowalls.

Regarding claim 45, Goto teaches the feed rate of the source material or feed rate of the radicals may be controlled based upon the density of the radicals in the reaction chamber [Goto, col 5, ln 5-46; col 2, ln 13-20], and since Hiramatsu suggests

the amount radicals affects the production of nanowalls, it would have been obvious to one of ordinary skill in the art to control the feed rate of all radicals or radical amount which is related to radical density in order to produce sufficient nanowalls.

Regarding claim 54, Hiramatsu teaches the carbon nanowalls are successfully deposited on a silicon (100) substrate [pg 4708, col 2] without indication of critically using metal catalyst on the substrate to generate such structures from the process; hence, it would have been inherent that such substrate would have no metal catalyst.

Regarding claim 58, since Hiramatsu teaches C2F6, CH4, and CF4 are suitable carbon sources for the production of nanowalls, it would have also been obvious to substitute fluorine for a hydrogen of methane, to yield a fluorinated hydrocarbon such as CHF3 as another carbon source for nanowalls, in light of methane and hexafluorethane being suitable carbon sources for nanowalls.

4. Claims 39, 45, 64, and 82 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hiramatsu in view of Goto, Wu, Chang, and further in view of Kirimura [US 6383896].

Teaching of the prior art is aforementioned, but appears to be silent in teaching the radicals are introduced in a direction perpendicular to a surface of the base material. Kirimura remedies this.

Regarding claim 39, Kirimura teaches a method and apparatus for providing radicals to a chamber [abstract], wherein the radical may be hydrogen [col 6, ln 25]. Kirimura further teaches the radicals may be introduced in a direction perpendicular to the surface of the base material [Fig. 1-3].

It would have been obvious to one of ordinary skill in the art at the time of the invention to provide the radicals in a direction perpendicular to the surface of the base material as suggested by Kirimura. One would have been motivated to do so to uniformly (non-impeded) emit the radicals to the target surface [Kirimura col 2, ln 61-65] so as to effectively form nanowalls over the entire surface of the base material from the reaction process.

In addition, regarding claim 45, Kirimura teaches controlling a feed rate of radicals (or plasmatization degree of the source material, col 3, ln 45-50) based on a concentration of the ion produced from a source gas and radical source gas [col 2, ln 45-52], which would innately be based upon on a concentration of either carbon radicals, hydrogen radicals, or fluorine radicals from the prior art teaching of using C2F6 as a carbon source gas and hydrogen gas as a radical source gas [Hiramatsu, pg 20, col 1].

It would have been obvious to one of ordinary skill in the art at the time of the invention to control the feed rate of the source material or feed rate based upon the concentration of radicals as suggested by Kimura. One would have been motivated to do so to reduce any potential plasma damage (or growth inhibition) to the product formation [Kimura, col 6, ln 45-50] caused by excessive number of radicals, and optimize the reaction between the materials.

Regarding claim 64, teaching of prior art is aforementioned, but appears to be silent in pretreating the base material by apply the radicals to the base material before plasmatizing the source material. Kirimura remedies this.

Regarding claim 64, Kirimura teaches a coating method and system for providing radicals to a chamber [abstract] wherein the prior art teaches pretreating the base material by apply radicals to the base material before plasmatizing the source material [col 6, ln 56-65].

It would have been obvious to one of ordinary skill in the art at the time of the invention to pretreat the base by applying the radicals before plasmatizing the source material as suggested by Kimura. One would have been motivated to do so in order to improve the interface between the substrate and a coating (i.e. prepare the surface for deposition) [Kimura, col 6, ln 56-65].

Regarding claim 82, Kirimura teaches the hydrogen radicals are generated at an upper area of the reaction chamber (PL2) [Fig. 1; col 8, ln 1-10].

It would have been obvious to one of ordinary skill in the art to generate the hydrogen radicals in an upper area of the reaction chamber. One would have been motivated to do so in order to enable distribution of the radials to the entire surface of the substrate uniformly [col 4, ln 40-45].

5. Claim 63 is rejected under 35 U.S.C. 103(a) as being unpatentable over Hiramatsu in view of Goto, Wu, Chang, and further in view of Lee [US 20020046953]

Teaching of prior art is aforementioned, but appears to be silent in teaching the limitation of orientating the nanostructure by tilting a line normal to the base material with respect to the direction of the electric field. Lee remedies this.

Regarding claim 63, Lee teaches the carbon structures may be orientated in the direction of a plasma discharge (i.e. electric field) wherein by either tilting the substrate

or electric source, the carbon structures may be formed at other angles to the substrate [0071].

It would have been obvious to one of ordinary skill in the art at the time of the invention to orient a nanostructure by tilting an electric field source. One would have been motivated to do so to achieve a tilt orientation if so desired (depended upon the function of the nanostructure in a device).

1. Claims 75 and 84 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hiramatsu in view of Wu [US 2002/0072249].

Regarding claim 75 and 84, Hiramatsu teaches a method for producing carbon nanowalls [title] comprising creating a plasma atmosphere in at least one region of a reaction chamber (main chamber) by plasmatizing a source material containing carbon; introducing radicals generated outside (remote source) the plasma atmosphere into the plasma atmosphere (i.e. reaction chamber); and growing carbon nanowalls on a base material (substrate) disposed in the reaction chamber [pg 20]. Hiramatsu further teaches the radicals are of hydrogen [pg 20, col 1], wherein the radicals are generated remotely (radicals generated other than a source gas plasmatizing area). However, Hiramatsu appears to be silent in teaching the source material comprising a compound selected form the group consisting of CH4, CF4, CHF3. Wu remedies this.

Regarding claim 75, Wu teaches methane (CH_4) may be a suitable carbon building source for forming nanowalls [0042].

It would have been obvious to one of ordinary skill in the art to provide methane as a carbon source to form nanowalls. One would have been motivated to do so to

choose a building materially that is known to effectively form carbon nanowalls and is readily available.

2. Claim 83 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hiramatsu in view of Wu, and further in view of Kirimura.

Teaching of the prior is aforementioned, but appears to be silent in teaching the limitation of claim 83. Kirimura remedies this.

Kirimura teaches the hydrogen radicals are generated at an upper area of the reaction chamber (PL2) [Fig. 1; col 8, ln 1-10].

It would have been obvious to one of ordinary skill in the art to generate the hydrogen radicals in an upper area of the reaction chamber. One would have been motivated to do so in order to enable distribution of the radials to the entire surface of the substrate uniformily [col 4, ln 40-45].

Claim Rejections - 35 USC § 102

1. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for a patent.
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

2. Claims 75 and 84 are rejected under 35 U.S.C. 102(b) as being anticipated by Hiramatsu [Fabrication of vertically aligned carbon nanowalls using capacitively coupled plasma enhanced chemical vapor deposition assisted by hydrogen radical injection].

Regarding claim 75, Hiramatsu teaches a method for producing carbon nanowalls [title], by creating a plasma atmosphere using a parallel plate rf, having a plasma generating area (CCP region) by providing carbon gas sources such as C2F6, CH4, or CF4 [pg 4708, col 2]; introducing hydrogen radicals from a remote radical source (injecting radicals generated outside the plasma atmosphere) [pg 4708, col 2] to produce carbon nanowalls on a substrate in the PECVD chamber [pg 4708, col 2].

Regarding claim 84, since Hiramatsu teaches the hydrogen radicals are introduced from a remote source area (quartz tube, ICP technique; pg 4708, col 2), it is inherent to the prior art that the hydrogen radicals are generated other than a source gas plasmatizing area.

Response to Arguments

6. Previous rejection under 35 USC 112, second paragraph is withdrawn, due to applicant's cancellation of claims 62 and 76.

7. Applicant's arguments with respect to claims 38-39, 45, 54, 58, 63-64, 75, 82-84 have been considered but are moot in view of the new ground(s) of rejection necessitated by amendments (i.e. decomposing a radical source in a radical generating area which is disposed in the reaction chamber).

8. Applicant's argument of Nagasawa, where there is no motivated to use the gases of Nagasawa for forming nanowalls or proven to produce nanowalls, such arguments were determined persuasive, particularly the types of gases that specific to the production of nanowalls, however are also moot in light of new grounds of rejection as provided above.

9. On a side note, applicant has distinguished carbon nanowalls from carbon nanotubes.

10. Applicant's arguments filed 12/03/10 have been fully considered but they are not persuasive.

Regarding applicant's argument of Hiramatsu, pg 6, failing to teach the radical generated in a radical generating area disposed in the reaction chamber is moot, since Goto is provided to teach such deficiency. See above rejection for more details.

Regarding applicant's argument of Goto drawn to forming different film than nanowalls; it is noted that Goto is relied upon to provide a radical generating area disposed in the reaction chamber so to effectively control the density or composition of the radicals.

Regarding applicant's argument of Kirimura disclosing a method for forming a silicon based film with uniform thickness, it is noted that Kirimura teaches the deposition gas and the radical material gas can be selected in accordance with the film to be formed [col 6, ln 14-16], suggesting that the system taught by Kirimura is open to a variety of different deposition films. Moreover, Kirimura is associated with the invention in which how decomposed radicals may be introduced to a chamber to treat a substrate

and form products on the substrate [abstract] as required by the recited claim. It is also noted that Kirimura teaches that the advantage is to supplying the radical uniformily to the substrate [col 4, ln 40-45].

Hence, arguments are not convincing, and rejections are maintained.

Conclusion

1. No claim is allowed.

2. Claims 38-39, 45, 54, 58, 63-64, 75, 82-84 are rejected for the reasons aforementioned.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MANDY C. LOUIE whose telephone number is (571)270-5353. The examiner can normally be reached on Monday to Friday, 7:30AM - 5:00PM EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Timothy Meeks can be reached on (571)272-1423. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/M. C. L./
Examiner, Art Unit 1715

/Timothy H Meeks/
Supervisory Patent Examiner, Art Unit 1715